

HCN content of the samples was different in the two seasons. The HCN content of the sorghums showed some tendency to be high where summer precipitation was lowest but there was no consistent relation between HCN content of sorghum and differences in temperature. Young feterita plants grown under abundant moisture conditions at Arlington, Va., contained as much HCN as the average for the six Great Plains stations where drought was severe.

The HCN content (calculated on a dry matter basis) of dried leaves of sorghum varieties ranged from about 12 percent to 75 percent of that of the whole green plant.

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ZOOLOGY.—*Predaceous nematodes of the genus Aphelenchoides from Hawaii.*<sup>1</sup> J. R. CHRISTIE, U. S. Bureau of Plant Industry.

In a recent publication Linford and Oliveira<sup>2</sup> pointed out that certain species of the nematode genus *Aphelenchoides* Fischer, 1894 are predaceous and number among their prey other nemas including the root-knot nematode, *Heterodera marioni* (Cornu, 1879) Goodey, 1932. These investigators have been able to rear five species of predaceous *Aphelenchoides* on agar cultures where their feeding habits could be studied. A population of some other nematode was first established on these cultures to provide food for the predators. Linford and

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<sup>2</sup> Science 85: 295-297. 1937.

Oliveira kindly forwarded to the writer cultures of these five *Aphelenchoides* species and the following descriptions and drawings are based on a study of the material thus provided. As the bionomics of these nematodes are being studied by the above mentioned investigators the present paper deals exclusively with taxonomy and morphology.

The species described herein belong to a group for which "long tailed" *Aphelenchoides* is perhaps an appropriate designation. The first of this group to be described was *Aphelenchoides longicaudatus* (Cobb, 1893) Goodey, 1933. This species is poorly characterized and probably unrecognizable but in one particular it seems to differ from all the subsequently described "long tailed" species including those described in the present paper: the length of the tail is at least twice as great as the distance from the vulva to the anus. The other species that have been added to this group are as follows: *A. tenuicaudatus* (de Man, 1895) Goodey, 1933, *A. winchesi* (Goodey, 1927) Filipjev, 1934, *A. demani* (Goodey, 1928) Goodey, 1933, *A. elmiraensis* van der Linde, 1938, and *A. oswegoensis* van der Linde, 1938.

Linford and Oliveira tentatively identified one of their species as *A. tenuicaudatus*. This identification apparently is correct. A second species is described herein as *A. winchesi* var. *filicaudatus*, n. var. The remaining three species are regarded as new and for these the names *A. linfordi*, n. sp., *A. oliveirae*, n. sp. and *A. oahuensis*, n. sp. are proposed.

There is considerable resemblance between females of some of these predacious *Aphelenchoides* and the female of *Seinura mali* Fuchs, 1931. The similarity of the stylet, the esophageal bulb and the tail is noticeable. Fuchs neither mentions nor figures the esophageal glands. On the other hand the tail of the male of *S. mali* differs conspicuously from that of all the predaceous species of which the male is known. Precisely what characters serve to differentiate the genus *Seinura* from the genus *Aphelenchoides* is not altogether clear to the writer but on the basis of Fuchs' description probably the male tail constitutes the most important differentiating character. If this is true none of the species described in the present paper belong in the genus *Seinura*.

As these five species of predaceous *Aphelenchoides* are quite similar in structure a few comments on their common morphological characteristics seem pertinent. Beginning at or somewhat anterior to the anus the body of the female tapers more or less evenly and ends in a long, pointed, conical tail. The longitudinal, cuticular modifications that define the so-called lateral fields of *A. parietinus* and *A. fragariae* were not observed. If such cuticular modifications occur they are very

indistinct. The head is more or less distinctly set off and is divided into six, slightly elevated, lip-like sectors. These lip-like elevations are slightly more conspicuous on some of the species (i.e. *A. tenuicaudatus*) than on others. The stylet is divided into an anterior, conical part and a posterior, cylindrical part with the anterior opening on the ventral side. At the junction of these two parts the stylet is encircled by a structure somewhat resembling the so-called guiding ring of dorylaids. This structure is most conspicuous in *A. tenuicaudatus* but is present and more or less distinct in all the species. The esophageal gland mass is exceptionally large. It is composed of a large gland, presumably the dorsal, constituting the posterior two-thirds or more of the mass and a pair of smaller glands, presumably the subventrals, constituting a greater part of the anterior third of the mass. The nucleus of the largest gland was seen in all the species but the nuclei of the smaller glands were more difficult to observe in toto preparations. Secretion from the esophageal glands fills a considerable area in the anterior part and a lesser area in the posterior part of the bulb with more or less secretion between these two areas just dorsal to the wall of the central lumen. The bulb is relatively large and somewhat elongated but varies considerably in shape, depending on the amount of secretion contained and the state of muscular contraction. Near the anterior end of the bulb the wall of the esophageal lumen is distinctly interrupted by at least one, or perhaps several, minute openings. Although undoubtedly present, phasmids were not observed, as a special technic necessary to make them visible was not employed.

The outlines of the drawings and all measurements were made on specimens killed in a 5 per cent solution of commercial formalin (about 2 per cent formaldehyde) heated to 70°C. Living specimens were used to determine many of the morphological details.

***Aphelenchoides winchesi* (Goodey) Filipjev var. *filicaudatus*, n. var.**

*Synonymy*.—*Aphelenchus winchesi* Goodey. Jour. Helminth. 5(4):2-7, figs. 1-5. 1927. *Aphelenchoides winchesi* (Goodey). Filipjev, *Harmful and useful nematodes in rural economy*. Moskva, Leningrad. p. 236, fig. 203, G-H. 1934.

*Measurements*.—♀: Length 800 to 880 $\mu$ ; width 23 to 26 $\mu$ ; length of esophagus, 80 to 86 $\mu$ ; length of tail, 138 to 187 $\mu$ ; a, 31 to 35;  $\beta$ , 9.7 to 10.6;  $\gamma$ , 4.5 to 6; V, 61 to 66%.

*Description*.—Male unknown. Female (Fig. 1,B) with cuticular striae fine, moderately obscure. Head region relatively short, only faintly set off. Stylet 18 to 19 $\mu$ , without basal knobs. Excretory pore from opposite middle to opposite posterior margin of esophageal bulb. Tail tapers more or less evenly and ends in a long filiform process. Anus very inconspicuous. Intestinal lumen between vulva and anus often wide and filled with fecal ma-



terial. Vulva relatively inconspicuous; postvulvar uterine sac very short; ovary outstretched, frequently extending nearly to nerve ring. Eggs 59 to 65 $\mu$  by 19 to 21 $\mu$ .

*Habitat.*—Soil.

*Locality.*—Island of Oahu, Territory of Hawaii, U.S.A.

*Comparisons and affinities.*—This variety, based on females only, differs from the type species in having (a) a longer tail (120 to 130 $\mu$  in type, 138 to 187 $\mu$  in present variety), (b) a shorter stylet (24 to 27 $\mu$  in type, 18 to 19 $\mu$  in present variety) and a somewhat more anteriorly situated excretory pore (“a short distance behind level of bulb” in type, from about opposite middle to about opposite posterior margin of bulb in present variety). In addition the vulva seems to be situated somewhat more anteriorly (at 70 to 75% in type, at 61 to 66% in present variety). As Linford and Oliveira had cultures of this variety under observation for a considerable period and neither they nor the present writer observed males, one may conclude that at least males are very rare. This constitutes another difference between the type species and the present variety.

### *Aphelenchoides tenuicaudatus* (de Man) Goodey

*Synonymy.*—*Aphelenchus tenuicaudatus* de Man. Trans. Liverpool Biol. Soc. 10: 77–81, pl. 3, figs. 1, 1a, 1b, & 1d, pl. 2, fig. 1c. 1895. *Aphelenchoides tenuicaudatus* (de Man). Goodey, *Plant parasitic nematodes and the diseases they cause*. London, p. 250, fig. 111. 1933.

*Measurements.*—♂: Length, 650 to 720 $\mu$ ; width, 17 to 21 $\mu$ ; length of esophagus, 76 to 87 $\mu$ ; length of tail, 45 to 56 $\mu$ ;  $\alpha$ , 34 to 40;  $\beta$ , 7.8 to 8.7;  $\gamma$ , 12.5 to 15.5. ♀: Length, 930 $\mu$  to 1 mm; width, 25 to 30 $\mu$ ; length of esophagus, 84 to 93 $\mu$ ; length of tail, 92 to 104 $\mu$ ;  $\alpha$ , 31 to 39;  $\beta$ , 10 to 11.2;  $\gamma$ , 9 to 10; V, 70 to 74%.

*Description.*—Cuticular striae fine, moderately obscure. Head region (Fig. 2,A) set off about as in *A. parietinus*, lip-like elevations relatively conspicuous. Stylet 14 to 16 $\mu$  long in males, 16 to 19 $\mu$  long in females; without basal knobs. Excretory pore opposite posterior end of esophageal bulb. Tail of female long and slender, tapering more or less evenly. Postvulvar uterine sac usually extending about one-half distance from vulva to anus but somewhat variable in size and shape. Ovary outstretched and extending past posterior end of esophageal glands, sometimes nearly to nerve ring. Tail of male (Fig. 2,B) somewhat similar in shape to that of female but tapering less abruptly in anterior two-thirds, then narrowing abruptly with posterior third in the form of a more or less slender terminal spike. Four pairs of papillae present; one pair about 8 to 10 $\mu$  in front of anus and nearly ventral, one pair opposite or slightly posterior to anus, and 2 pairs, 4 or 5 $\mu$  apart, near middle of tail. Spicule 18 to 20 $\mu$  long with shape as shown in Figure 2,B.

*Habitat.*—Soil.

*Locality.*—Islands of Oahu and Maui, Territory of Hawaii, U.S.A.

*Comparisons and affinities.*—The writer's material agreed fairly closely with both de Man's and Goodey's descriptions. The most conspicuous difference was the length of the stylet which, in females, measured only 16 to 19 $\mu$  as against 24 to 27 $\mu$  in de Man's material.

*A. elmiraensis* resembles *A. tenuicaudatus* more closely than it resembles any other described species. It differs in the length of the tail in both sexes and in the length of the stylet. The stylet is only 10 $\mu$  long and  $\gamma$ , in the female, is about 4.5, while in the male tail of *A. elmiraensis* the terminal portion posterior to the papillae is considerably longer than in *A. tenuicaudatus*.

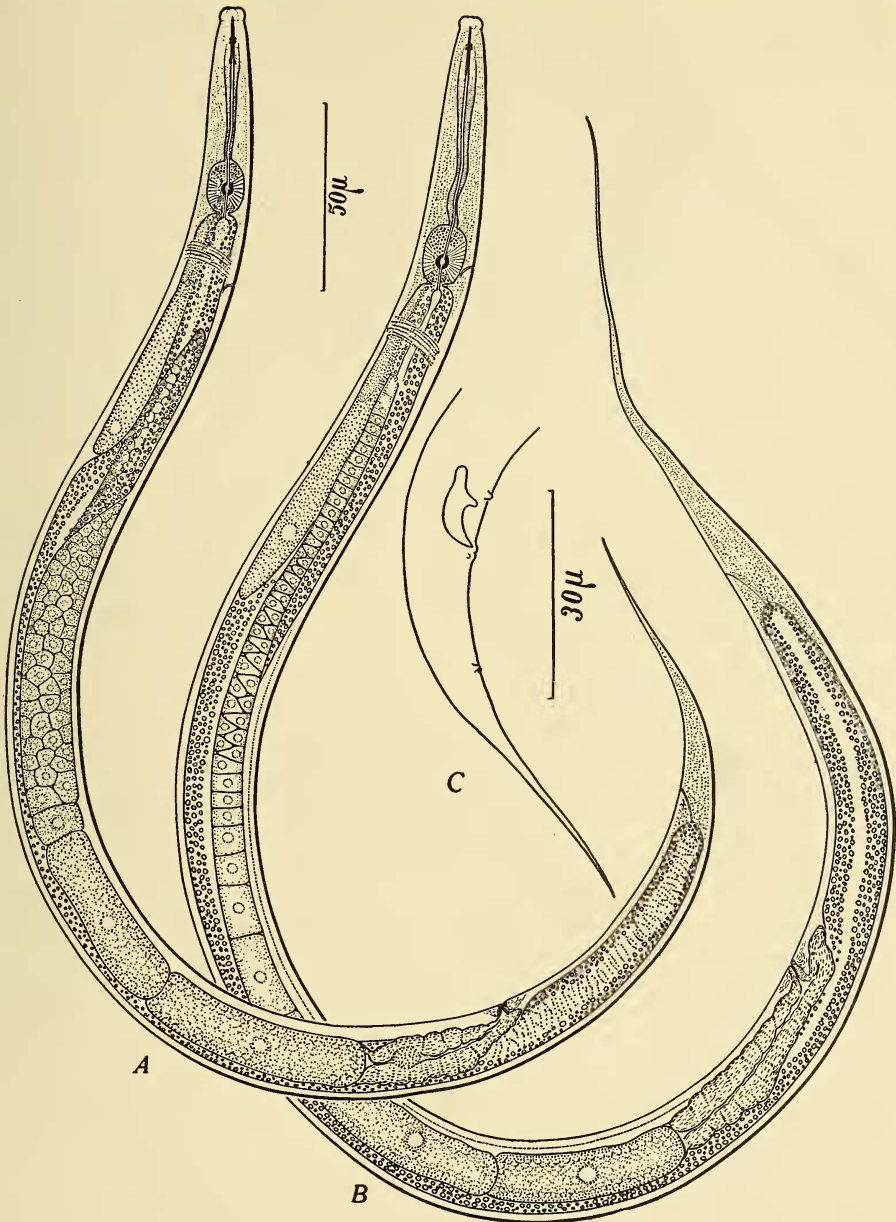


Fig. 1. A.—*Aphelenchoides oliveirae*, n.sp., female. B.—*A. winchesi* var. *filicaudatus*, n. var., female. C.—*A. oliveirae*, n.sp., tail of male.

*datum*. In fact the tail of the female of *A. elmiraensis* approaches in length that of *A. longicaudatus* being about  $1\frac{1}{2}$  times as great as the distance from vulva to anus. Van der Linde was probably justified in regarding *A. elmiraensis* as a distinct species but as other populations become known its dif-

ferentiation may become increasingly difficult. That, of course, is equally true of some of the species described in the present paper.

***Aphelenchoides linfordi*, n. sp.**

*Measurements*.—♂: Length, 500 to 600 $\mu$ ; width, 20 to 23 $\mu$ ; length of esophagus, 61 to 66 $\mu$ ; length of tail, 52 to 64 $\mu$ ;  $\alpha$ , 24 to 27;  $\beta$ , 8 to 9.3;  $\gamma$ , 8.3 to 10.9; V, 71 to 75%.

*Description*.—Male unknown. Female (Fig. 3,B) with conspicuous, transverse cuticular striae forming distinct annules as much as 2 $\mu$  wide near middle of body. Head region moderately well set off. Stylet 16 to 17 $\mu$  long, without basal knobs. Excretory pore posterior to base of esophagus a distance equal to, or slightly less than, the corresponding body diameter. Tail tapers more or less evenly and ends in a moderately slender terminal portion, cuticular striae conspicuous for entire length. Postvulvar uterine sac short but usually rather wide. Ovary outstretched and extending to or slightly passing posterior end of esophageal glands. Eggs 62 to 68 $\mu$  by 21 to 22 $\mu$ .

*Habitat*.—Soil.

*Locality*.—Island of Oahu, Territory of Hawaii, U.S.A.

*Comparisons and affinities*.—That *Aphelenchoides linfordi* belongs to this group of "long tailed" *Aphelenchoides* is evidenced by its predacious habit and by its large and conspicuous esophageal glands. It differs from all other species of the group in having moderately coarse and conspicuous transverse striae. In addition females are somewhat shorter than those of any other related species and the width is relatively greater ( $\alpha$ , 24 to 27) than in females of any other species except *A. oliveirae* ( $\alpha$ , 25 to 32).

***Aphelenchoides oliveirae*, n. sp.**

*Measurements*.—♂: Length, 384 to 484 $\mu$ ; width, 13 to 17 $\mu$ ; length of esophagus, 57 to 64 $\mu$ ; length of tail, 54 to 61 $\mu$ ;  $\alpha$ , 28 to 32;  $\beta$ , 6.7 to 7.9;  $\gamma$ , 7 to 8.6. ♀: Length, 600 to 720 $\mu$ ; width, 20 to 27 $\mu$ ; length of esophagus, 60 to 67 $\mu$ ; length of tail, 82 to 94 $\mu$ ;  $\alpha$ , 25 to 32;  $\beta$ , 9.2 to 11;  $\gamma$ , 6.7 to 8.5; V, 69 to 73%.

*Description*.—Cuticular striae fine, moderately inconspicuous. Head region (Fig. 1,A) comparatively short, only faintly set off. Stylet 14 to 15 $\mu$  long in males, 15 to 16 $\mu$  long in females, with small but distinct basal knobs. Excretory pore posterior to base of esophagus a distance equal to, or slightly less than, the corresponding body diameter. Tail of female tapers more or less evenly and ends in a slender terminal portion. Intestinal lumen between vulva and anus frequently wide and filled with fecal material. Anus very minute, indistinguishable in many specimens. Ovary outstretched, frequently extending nearly to nerve ring; posterior part wide showing several oöcytes in a given cross section. Postvulvar uterine sac virtually absent. Eggs 70 to 83 $\mu$  by 18 to 19 $\mu$  (based on eggs in relatively advanced stages of development). Tail of male (Fig. 1,C) similar in shape to that of female. Two pairs of papillae present, one pair about 8 $\mu$  in front of anus and one pair about 18 $\mu$  posterior to anus; a pair of adanal papillae probably present. Spicule about 14 $\mu$  long and shaped as shown in Figure 1,C.

*Habitat*.—Soil.

*Locality*.—Island of Maui, Territory of Hawaii, U.S.A.

*Comparisons and affinities*.—This species differs from *A. demani* in having a shorter tail in both sexes. In his original description of *A. demani* Goodey

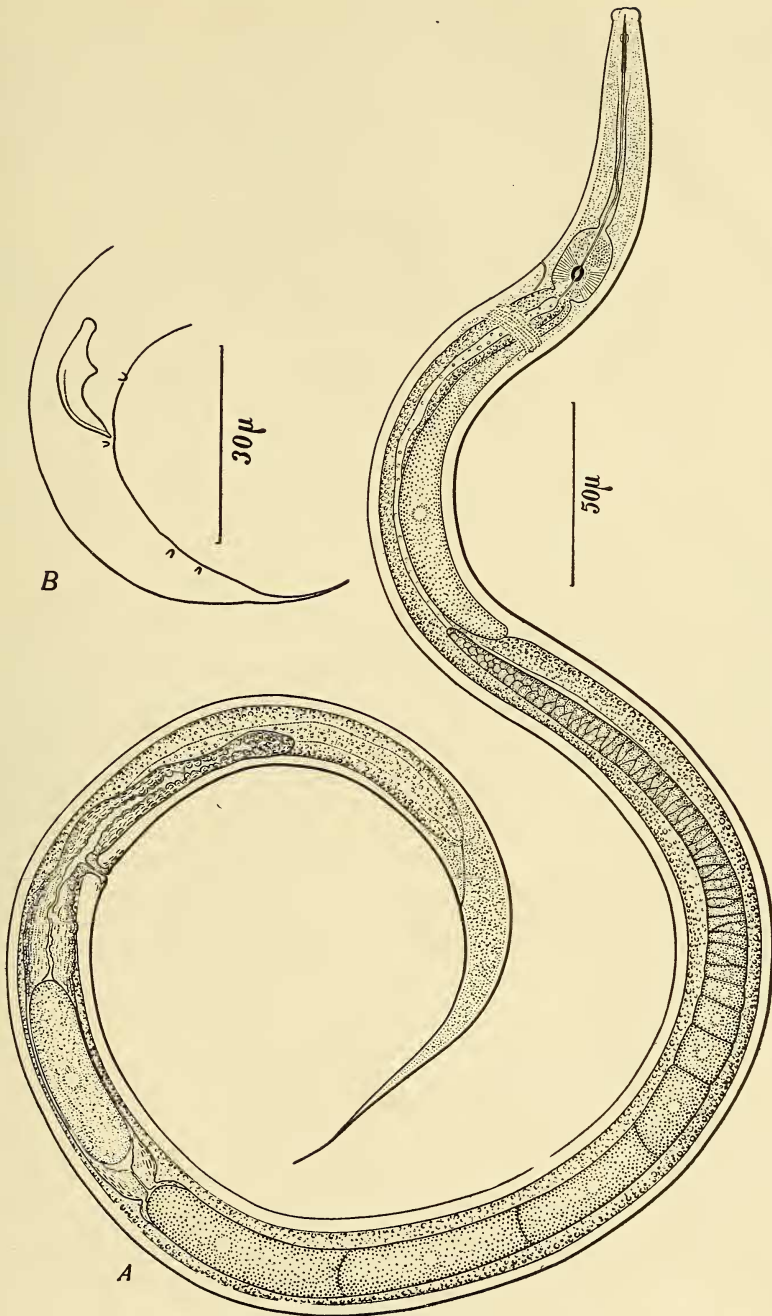


Fig. 2. A.—*Aphelenchoides tenuicaudatus*, female.  
B.—*A. tenuicaudatus*, tail of male.



writes of the vagina as having stout walls while in the present species the vagina is relatively small and inconspicuous. The exceptionally wide ovary showing, toward its posterior end, several oöcytes in a cross section, may prove to be another, and a more important, difference. The posterior half of the male tail does not seem to be quite so clearly differentiated as in that of *A. demani* but the arrangement of the papillae in the two species seems to be identical.

*Aphelenchoides oahuënsis*, n. sp.

*Measurements.*—♀: Length, 760 to 860 $\mu$ ; width, 20 to 22 $\mu$ ; length of esophagus, 67 to 76 $\mu$ ; length of tail, 55 to 66 $\mu$ ;  $\alpha$ , 35 to 40;  $\beta$ , 9.6 to 11.9;  $\gamma$ , 13 to 15; V, 69 to 75%.

*Description.*—Male unknown. Female (Fig. 3,B) with cuticular striae fine, moderately obscure. Head set off about as in *A. parietinus*. Stylet 14 to 15 $\mu$  long with small but distinct basal knobs. Excretory pore inconspicuous, situated posterior to base of esophagus a distance about equal to corresponding body diameter. Tail tapers more or less evenly and ends in a slender terminal portion usually somewhat constricted near middle region. Postvulvar uterine sac usually extending about one-third distance from vulva to anus. Ovary outstretched, frequently extending nearly to nerve ring. Anus small and inconspicuous.

*Habitat.*—Soil.

*Locality.*—Island of Oahu, Territory of Hawaii, U.S.A.

*Comparisons and affinities.*—This species very closely resembles both *A. demani* and *A. oliveirae*. The female differs from that of *A. demani* in possessing a short postvulvar uterine sac and a shorter tail that is slightly constricted. It differs from *A. oliveirae* in having a postvulvar uterine sac, a narrower ovary, a longer and thinner walled uterus and a slightly constricted tail. Although probably not a point of taxonomic significance it may be noted that males were not present on the cultures of this species whereby it differs from the two other closely related species. The writer gave careful consideration to the advisability of regarding both the present species and *A. oliveirae* as varieties of *A. demani*. He finally decided that *A. oliveirae* and *A. oahuënsis* should be regarded as distinct species, the decision being influenced largely by differences in the female reproductive organs. If this is true, both forms obviously cannot be varieties of *A. demani* and the question arose as to which, if either, should be so regarded. In view of his inability to satisfactorily answer this question the writer decided, somewhat reluctantly, to regard each as a distinct species.

Apparently *Aphelenchoides* is a genus in which a great many of the populations that come to ones attention differ in some minor particular from those previously studied. This is certainly true for what now passes as *A. parietinus* and likewise it appears to be true for this group of "long-tailed," predaceous forms. What the confines of the species should be is a question for which only time and experience will provide an answer. It appears, however, that in many cases specific diagnoses must be sufficiently elastic to permit considerable variation or we will soon find ourselves with a vast number of species differentiated by minor and exceedingly variable characters.

As males are known for only part of the species the following key is based on the females. Information regarding the male tail is supplementary and is included for convenience in the hope that it may, at times, prove useful.



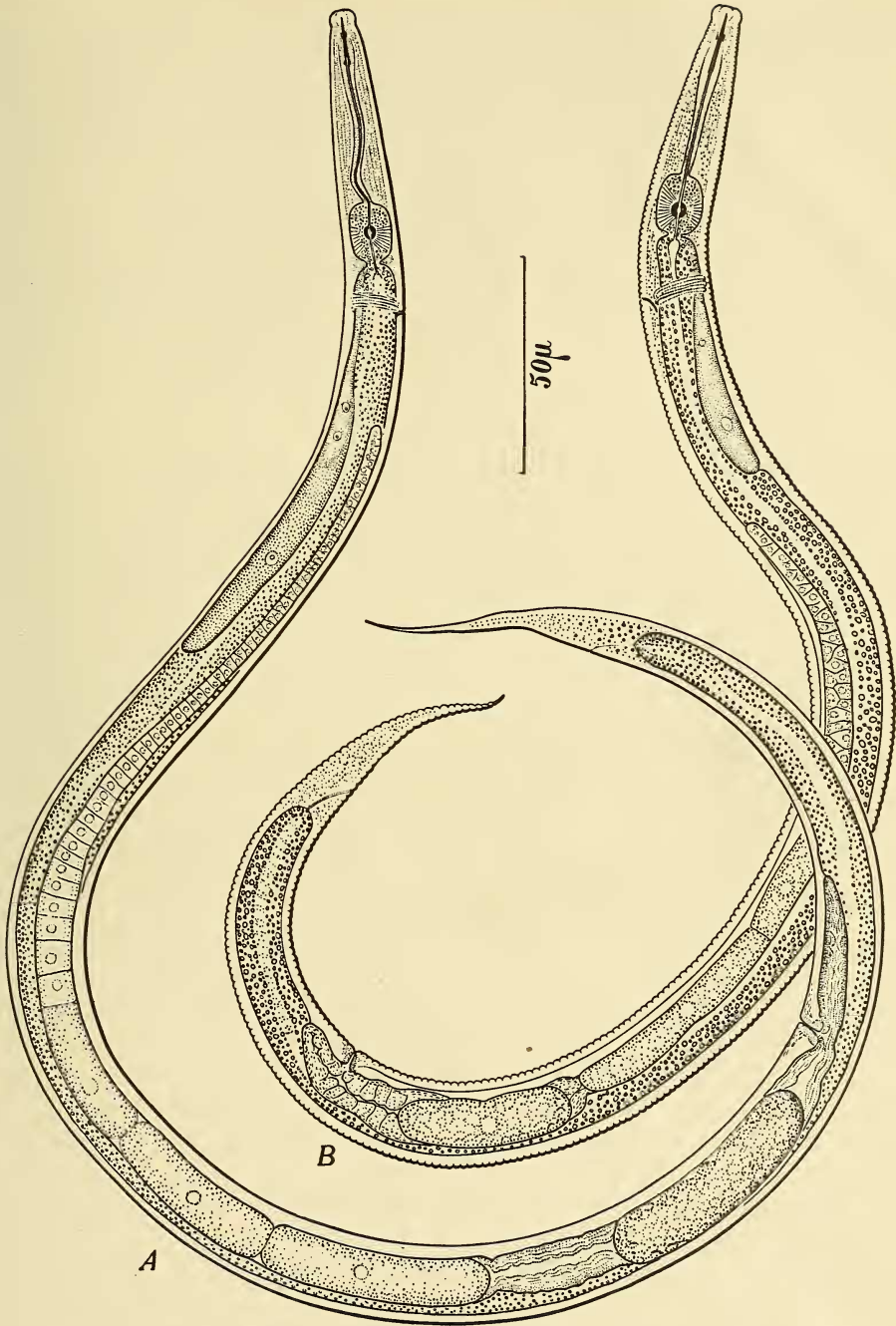


Fig. 3. A.—*Aphelenchoides oahuensis*, n. sp. female.  
B.—*A. linfordi*, n. sp., female.

The separation of *A. longicaudatus* obviously is unsatisfactory as the relative length of the female tail is subject to considerable variation. Cobb's description does not give precise information regarding the anatomical features upon which the key is primarily based and the long tail of the female seems to be the only character that can serve to differentiate this species.

KEY TO SPECIES OF "LONG-TAILED" APHELENCHOIDES  
DISCUSSED IN THIS PAPER

1. Length of tail in female at least twice as great as distance from vulva to anus..... *longicaudatus*  
Length of tail in female not over one and one-half times as great as distance from vulva to anus..... 2
2. Stylet with small but distinct basal swellings or knobs..... 3  
Stylet without basal swellings or knobs..... 5
3. Postvulvar uterine sac well developed often extending nearly one-third distance from vulva to anus; male unknown..... *oahuënsis*  
Postvulvar uterine sac, if present, very short; both sexes usually encountered; male tail with one pair preanal, one pair indistinct adanal and one pair postanal papillae..... 4
4. Vagina with stout walls and presumably moderately large and conspicuous; excretory pore a short distance behind bulb but in front of nerve ring;  $\gamma$ , in female, usually 5.3 to 6.5; posterior half of male tail set off..... *demani*  
Vagina small and inconspicuous; excretory pore opposite or slightly behind nerve ring;  $\gamma$ , in female, 6.7 to 8.5; posterior half of male tail only faintly set off..... *oliveirae*
5. Body of female with conspicuous and moderately coarse transverse striae forming distinct annules; male unknown..... *linfordi*  
Body of female with inconspicuous transverse striae..... 6
6. Postvulvar uterine sac absent or very short; male tail with one pair of indistinct adanal and one pair of postanal papillae..... *winchesi*  
Postvulvar uterine sac well developed usually extending at least half way from vulva to anus..... 7
7. Stylet short, about  $10\mu$  long; vulva relatively far anterior, at about 62%; tail exceptionally long and slender,  $\gamma$ , in female, about 4.5; male tail with one pair of preanal, one pair of adanal and two pairs of postanal papillae..... *elmiraensis*  
Stylet  $14\mu$  long or longer; vulva at 66% or more;  $\gamma$ , in female, 7 or more..... 8
8. Lips faintly developed; tail of female relatively short,  $\gamma$ , about 12; male unknown..... *oswegoensis*  
Lips well developed; tail of female slender and attenuated,  $\gamma$ , 7.7 to 11; male with one pair preanal, one pair indistinct adanal and two pairs of postanal papillae..... *tenuicaudatus*